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International application number: PCT/GB05/002999

International filing date: 29 July 2005 (29.07.2005)

Document type: Certified copy of priority document

Document details: Country/Office: GB  
Number: 0416915.7  
Filing date: 29 July 2004 (29.07.2004)

Date of receipt at the International Bureau: 30 September 2005 (30.09.2005)

Remark: Priority document submitted or transmitted to the International Bureau in compliance with Rule 17.1(a) or (b)



World Intellectual Property Organization (WIPO) - Geneva, Switzerland  
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PCT/GB2005/002999



INVESTOR IN PEOPLE

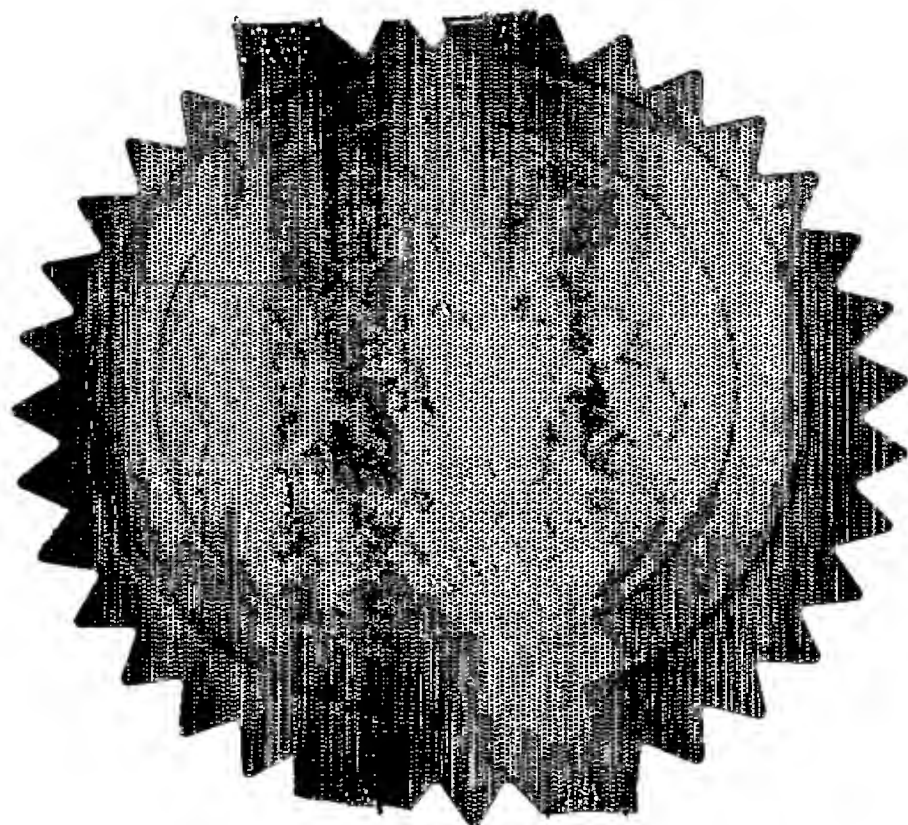
The Patent Office  
Concept House  
Cardiff Road  
Newport  
South Wales  
NP10 8QQ

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Signed

Dated 21 September 2005

# Patents Form 1/77

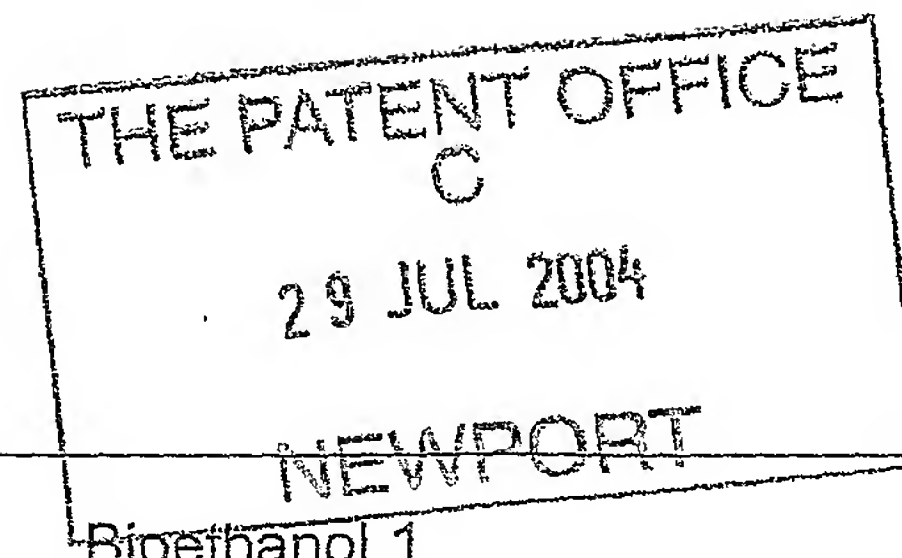
Patents Act 1977  
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29JUL04 E915054-2 R22003  
FOI/7700 0.00-0416915.7 NONE

## Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)



The Patent Office

Cardiff Road  
Newport  
South Wales  
NP10 8QQ

1. Your reference

2. Patent application number

(The Patent Office will fill this part in)

0416915.7

29 JUL 2004

3. Full name, address and postcode of the or of each applicant (underline all surnames)

Patents ADP number (*if you know it*)

If the applicant is a corporate body, give the country/state of its incorporation

Pursuit Dynamics PLC  
Unit 1 Anglian Business Park  
Orchard Road  
Royston  
Hertfordshire  
SG8 5TW

8333072002

4. Title of the invention

Biofuel Processing

5. Name of your agent (*if you have one*)

"Address for service" in the United Kingdom to which all correspondence should be sent (*including the postcode*)

Patents ADP number (*if you know it*)

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6-LINCOLN  
E5 8PUB

6. Priority: Complete this section if you are declaring priority from one or more earlier patent applications, filed in the last 12 months.

Country

Priority application number  
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Date of filing  
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7. Divisionals, etc: Complete this section only if this application is a divisional application or resulted from an entitlement dispute (see note f)

Number of earlier UK application

Date of filing  
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8. Is a Patents Form 7/77 (Statement of inventorship and of right to grant of a patent) required in support of this request?

Answer YES if:

- a) any applicant named in part 3 is not an inventor, or
- b) there is an inventor who is not named as an applicant, or
- c) any named applicant is a corporate body.

Otherwise answer NO (See note d)

Yes

# Patents Form 1/77

9. Accompanying documents: A patent application must include a description of the invention. Not counting duplicates, please enter the number of pages of each item accompanying this form:

Continuation sheets of this form

Description 4

Claim(s)

Abstract

Drawing(s)

DM

10. If you are also filing any of the following, state how many against each item.

Priority documents

Translations of priority documents

Statement of inventorship and right to grant of a patent (Patents Form 7/77)

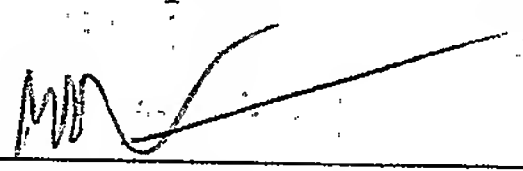
Request for a preliminary examination and search (Patents Form 9/77)

Request for a substantive examination (Patents Form 10/77)

Any other documents (please specify)

11. I/We request the grant of a patent on the basis of this application.

Signature(s)



Date

28/7/04

12. Name, daytime telephone number and e-mail address, if any, of person to contact in the United Kingdom

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## Biofuel Processing

This invention relates to a method of enhancing Biofuel production.

The present invention has reference to a method of enhancing the production of biofuels, with application to, but not restricted to, the production of bioethanol. The present invention has reference to the production of bioethanol using the Acid Hydrolysis and Enzymatic Hydrolysis processes.

It is well known in the art that bioethanol fuel is mainly produced by the sugar fermentation process. The main sources of sugar required to produce ethanol come from fuel or energy crops. These crops are grown specifically for energy use and include corn, maize and wheat crops, waste straw, willow and poplar trees, sawdust, reed canary grass, cord grasses, Jerusalem artichoke, miscanthus and sorghum plants. There is also ongoing research and development into the use of municipal solid wastes to produce ethanol fuel.

Bioethanol has a number of advantages over conventional fuels. It comes from a renewable resource i.e. crops and not from a finite resource and the crops it derives from are easily grown (like cereals, sugar beet and maize). Another benefit over fossil fuels is the greenhouse gas emissions. The road transport network accounts for a large percentage of all greenhouse gas emissions such as CO<sub>2</sub>. Through the use of bioethanol some of these emissions will be reduced as the fuel crops actually absorb some of the CO<sub>2</sub> whilst growing. Also, blending bioethanol with petrol will help extend the life of the worlds diminishing oil supplies and avoid heavy reliance on oil producing nations. Bioethanol is also biodegradable and far less toxic than fossil fuels.

Ethanol can be produced from biomass by the hydrolysis and sugar fermentation processes. Biomass waste contains a complex mixture of carbohydrate polymers from the plant cell walls known as cellulose, hemicellulose and lignin. In order to produce sugars from the biomass, the biomass is pre-treated with acids or enzymes in order to reduce the size of the feedstock and to open up the plant structure. The cellulose and the hemicellulose portions are broken down (hydrolysed) by enzymes or dilute acids into sucrose

(sugar) that is then fermented into ethanol. The lignin which is also present in the biomass is normally used as a fuel for the ethanol production plant's boilers. There are three principle methods of extracting sugars from biomass. These are Concentrated Acid Hydrolysis, Dilute Acid Hydrolysis and Enzymatic Hydrolysis.

The Concentrated Acid Hydrolysis, or Arkanol process typically works by adding 70-77% sulphuric acid to the biomass that has been dried to a 10% moisture content. The acid is added in the ratio of 1.25 acid to 1 biomass and the temperature is controlled to 50°C. Water is then added to dilute the acid to 20-30% and the mixture is again heated to 100°C for 1 hour. The gel produced from this mixture is then pressed to release an acid sugar mixture and a chromatographic column is used to separate the acid and sugar mixture.

In the Dilute Acid Hydrolysis process, dilute acid is used to hydrolyse the biomass to sucrose. The first stage uses 0.7% sulphuric acid at 190°C to hydrolyse the hemi cellulose present in the biomass. The second stage is optimised to yield the more resistant cellulose fraction. This is achieved by using 0.4% sulphuric acid at 215°C. The liquid hydrolyates are then neutralised and recovered from the process.

In the alternative Enzymatic Hydrolysis process, instead of using acid to hydrolyse the biomass into sucrose, enzymes are used to break down the biomass in a similar way.

The method of the present invention is to pass the process fluid, through a Fluid Mover of the kind described in our International Patent Application No PCT/GB2003/004400 in which the interaction of a process fluid or fluids and steam projected from a nozzle arrangement provides pumping, entrainment, maceration, mixing, heating, emulsification, homogenization etc of the process fluid or fluids. In this application the process fluid may be comprised of the biomass suspended in a liquid medium, for example water, or it may be a mixture of liquids (for example water and sulphuric acid).

The Fluid Mover introduces an annular supersonic jet of transport fluid, typically steam, into a relatively large diameter straight through hollow passage. Through a combination

of momentum transfer, high shear, and the generation of a supersonic shockwave, the high velocity steam induces and acts upon the process fluid passing through the centre of the hollow body.

This Fluid Mover is particularly suitable for use in processing fluids such as liquid/solids suspensions such as biomass due to its ability to handle high fluid viscosities and large solid particle sizes. It is therefore almost impossible to block. In addition, due to its lack of moving parts, and subsequent lack of bearings, dynamic seals, and dynamic clearances, the Fluid Mover is resistant to chemical or acid damage and has Clean in Place (CIP) properties.

The nature of the energy transfer between the steam and the process fluid affords significant advantages for use in bioethanol production. Due to the intimate mixing between the hot transport fluid (steam) and the process fluid, very high heat transfer rates between the fluids are achieved resulting in rapid heating of the process fluid. In addition, the high energy intensity within the unit, especially the high momentum transfer rates between the steam and process fluid result in high shear forces on the process fluid.

Two or more Fluid Movers may be used in series, each Fluid Mover may be configured and optimized to carry out different roles. For example, one Fluid Mover may be configured to pump and mix (and do some initial heating) and a second Fluid Mover mounted in series down stream of the first, optimized to heat and macerate.

Alternatively, the process fluid may be fed through the Fluid Mover by an external pressure means, for example via another pump, or a gravity pressure head. In this scenario the Fluid Mover would not be required to provide a pumping action, but would be configured for optimum heating, mixing, maceration etc. This may have particular application in cases where high temperature (up to 100°C) operation is required.

In still yet another alternative, the Fluid Mover may be operated within an externally controlled pressure environment. For example, the inlet and exit pressures of the process

fluid through the Fluid Mover are externally regulated to provide an elevated working pressure within the body of the Fluid Mover. This would provide the opportunity to operate the Fluid Mover at higher temperatures, i.e. maintaining steam condensation at temperatures higher than 100°C.

Utilising the method described in this invention, the process of mixing, heating, hydrating and macerating the carbohydrate polymers in the biomass can be achieved more rapidly and efficiently than conventional methods. Utilising the high shear and the presence of shockwave allows the active chemical or biological components to be intimately mixed with the carbohydrate polymers more efficiently, enhancing the contact through pulping of the plant matter as it begins to breakdown. Although the method described in this invention utilizes high temperature and high shear, it is still suitable for use in the Enzymatic Hydrolysis process without damage to the enzymes. It has been found in other applications, for example in the mashing-in process in the brewing industry, that the processing of the process fluid can be achieved whilst maintaining the integrity of the enzymes in the mash. In this application maintaining the integrity of the enzymes in the mix is important as they are required to convert the starch to sugar in a later process.

The energy intensity within the Fluid Mover is controllable. By controlling the flow rates of the steam and/or the process fluid, the intensity can be reduced to allow slow heating of the process fluid, and provide much lower shear intensity. This could be used, for example, to provide gentle heating of the process fluid to maintain a batch of process fluid at a constant temperature.